EV-Smart Grid Research & Interoperability Activities

2014 DOE Hydrogen Program and Vehicle Technologies Annual Merit Review

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Project ID #VSS095

Overview

Timeline

- Codes & standards support, grid connectivity R&D and international cooperation initiated FY 2010
- DOE-JRC agreement to establish interoperability centers - Q1, FY 2012
  Official Argonne launch - Q4, FY 2013

Barriers/Challenges

- Lack of universal EV-EVSE compatibility and EV-EVSE-grid interoperability
- Development and verification of technology and standards in time to support OEM and supplier production schedules
- Lack of harmonization in global markets with common OEMs and suppliers

Budget*

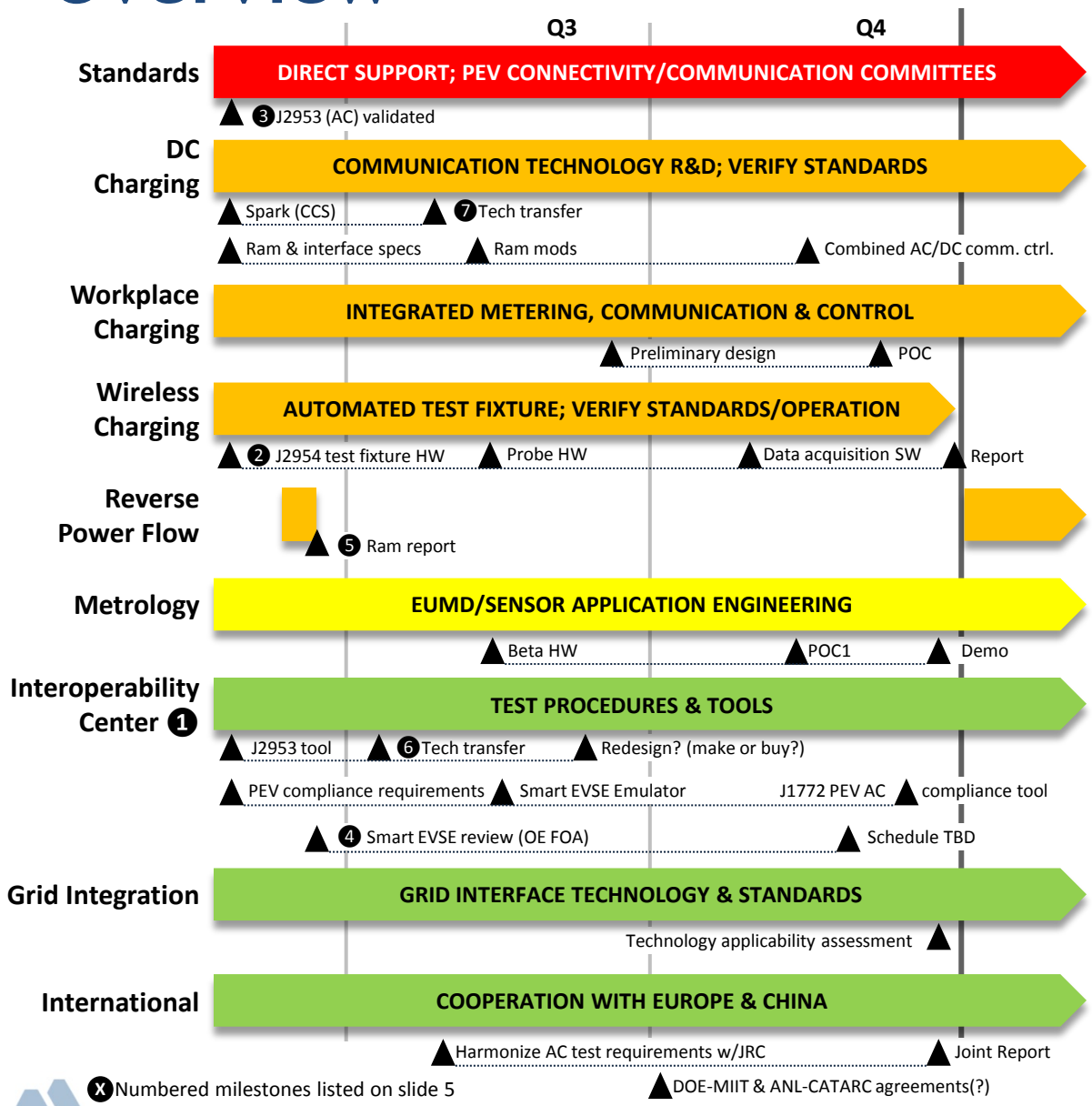
- FY2012 – $1180 K
- FY2013 – $2200 K
- FY2014 – $1550 K

* Combined - Codes & Standards Support, Grid Connectivity R&D, International Cooperation and EV-Smart Grid Interoperability Center (funding began in FY 2013)

Partners/Collaborators

- Standards definition organizations (SDOs)
- Vehicle, EVSE and W-EVSE OEMs, utilities
- National labs (INL, PNNL, ORNL, NREL)
- NRTL certification labs (UL, ETL, TUV SÜD)

Overview



FY 2015

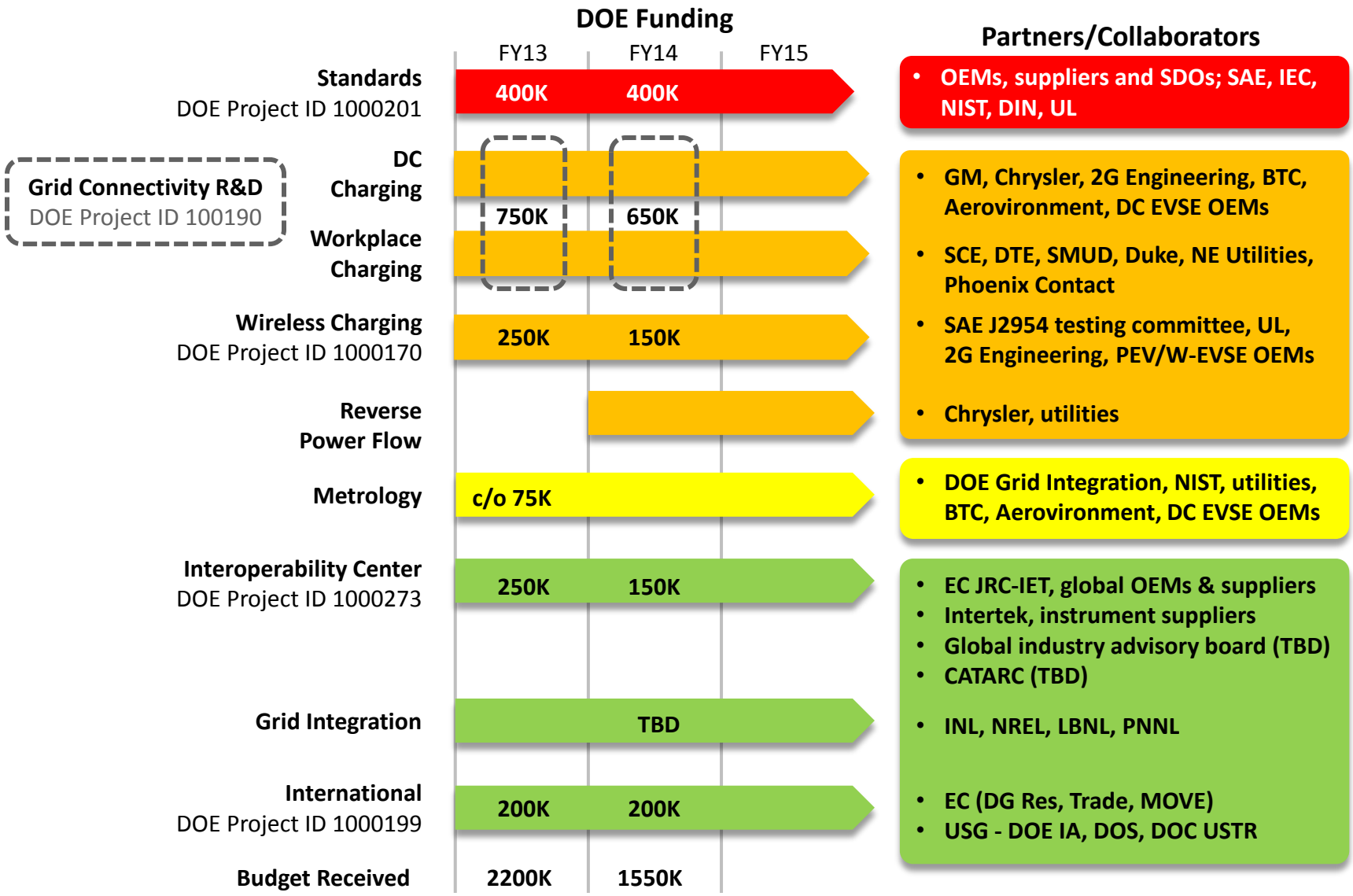
- **DC interoperability focus**
- **SAE, IEC, UL, etc.**

- **DC compliance/interoperability test procedures and tools**
- **System integration/verification**
- **SW development**
- **System integration/verification**
- **Tech transfer**
- **Focus on off-board inverter**

- **SW development/HW integration**
- **Tech transfer**

- **PEV J1772 compliance testing**
- **DC interoperability testing**
- **Magnetic interoperability testing**
- **Tech transfer**
- **Design studies/prototypes**
- **System integration with NREL**
- **Harmonize procedures and tools**
- **Initiate joint testing**
- **Establish common industry board**
- **Joint work plan with CATARC (TBD)**

Collaboration/Coordination



Milestones

Month/Year	Milestone
Jul 2013	❶ Launched EV-Smart Grid Interoperability Center at Argonne in Q4 2013; demonstrated integrated energy management of real PEVs and EVSEs in workplace charging situation using grid simulation and real-time data
Jul 2013	❷ Developed SAE J2954 wireless charging test fixture; 3-D manipulation of vehicle/transmitter; installed electromagnetic isolation chamber
Feb 2014	❸ Drafted and validated SAE J2953 AC interoperability standard in cooperation with SAE committee members
Feb 2014	❹ Evaluated smart EVSE deliverable from OE FOA
Mar 2014	❺ Evaluated ARRA-funded Chrysler Ram with reverse power flow
Apr 2014	❻ Developed SAE J2953 AC interoperability verification tools, transferred equipment and software
Sep 2013-Apr 2014	❼ Developed standards-compliant charging communication controllers (i.e., SAE J1772, J2847/2 and J2931/1&4); applied to EVSEs and high power DC PEV/EVSE emulation … licensed technology

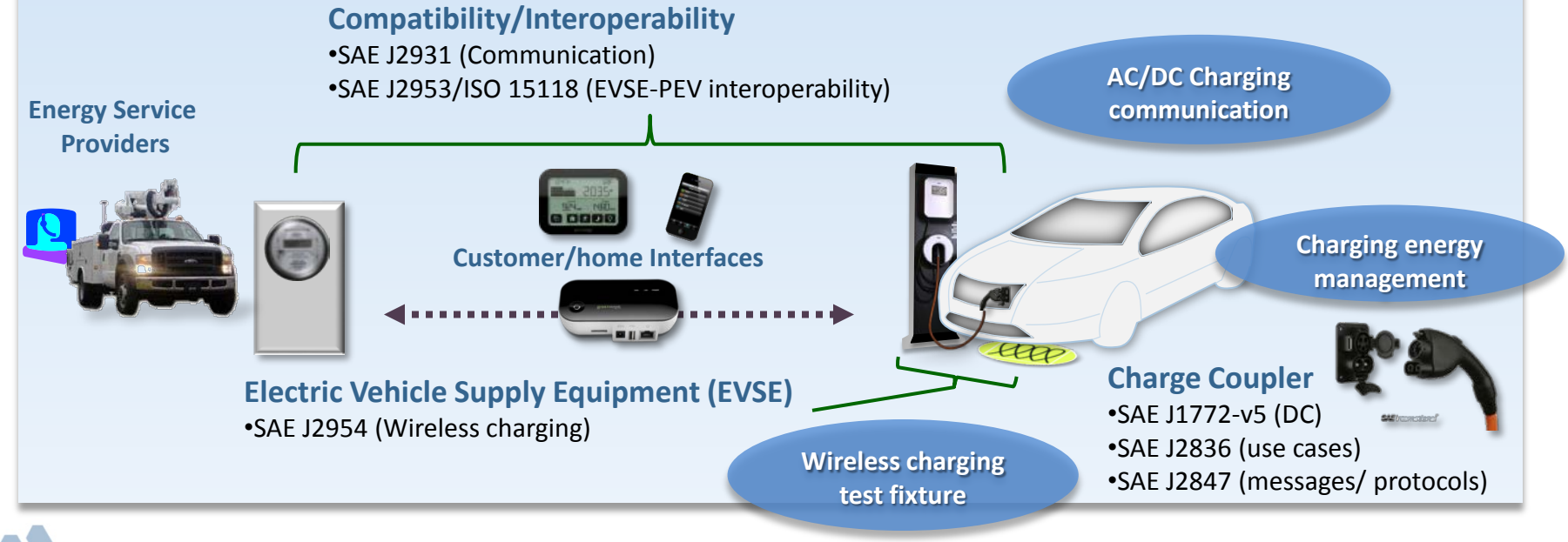
Relevance/Objectives

- **Directly support standards definition organization (SDO) committee activities**; cooperate on development and verification of PEV-grid connectivity and communication standards and technology
- **Utilize lab capabilities to complement standards development and/or verification;** develop compliance and interoperability tools, charging communication control and EVSE load management
- **Facilitate global harmonization**; establish cooperative EV-Smart Grid Interoperability Centers in Europe and Asia (TBD)

Scope: Connectivity and communication between light duty PEVs, the charging infrastructure and the energy service provider interface

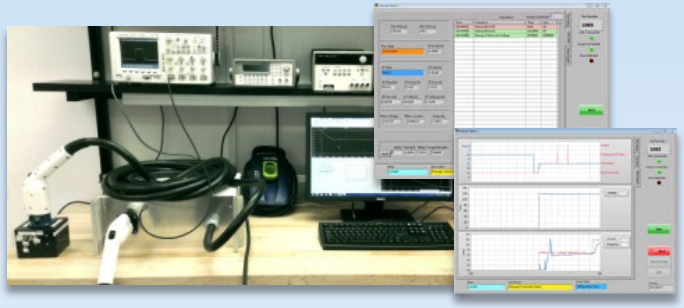
Approach

- **Align activities with standards development**; develop/verify communication protocols, test procedures, tools and enabling technologies
- **Combine embedded controls and vehicle lab to establish Argonne interoperability center**; collaborate with EC JRC-Institute for Energy & Transport to establish center in EU

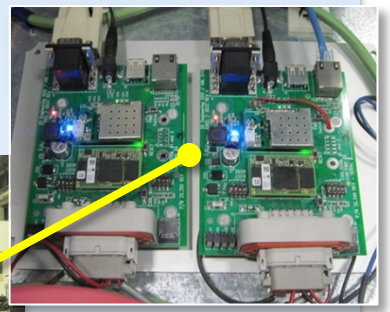


Accomplishments … Tools/Technology

- **Test procedures and tools**
  - SAE J2953 compatibility/interoperability
  - SAE J1772 connector force measurement
  - SAE J2954 wireless charging test fixture



- **Charging communication controllers**
  - PEV/EVSE communication and emulation



Accomplishments … Interoperability Center

200kW/480VAC Power

Integrated grid simulation, real-time grid data, and configurable branch circuit for smart charging and energy management studies

Electromagnetic isolation chamber w/ wireless charging test fixture

Interoperability test tools

150kW+ PEV/EVSE emulator

AC and DC EV Supply Equipment

Wireless test fixture

Embedded controls lab

Response to FY 2013 Comments

- **Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts**
  - Positive response … no issues
- **Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals**
  - Positive response … slow progress of standards committees was mentioned
    Industry is responsible for standards definition and the review/balloting schedule
- **Question 3: Collaboration and coordination with other institutions**
  - Generally positive response … though reviewers suggested that 1) more utilities could be involved, 2) NIST standards development should be supported and 3) that more international collaboration was required.
    1) Technical issues are discussed regularly with utilities; they participate in the Grid Interaction Tech Team (U.S. DRIVE) and standards committees they deem appropriate.
    2) Argonne chairs a NIST sub-committee related to metering, however NIST is an agency of DOC and Argonne support is at the discretion of DOE.
    3) International collaboration is limited primarily by availability (workload) of technical staff. Argonne participates in some IEC committee activities and cooperates with JRC-IET and industry w.r.t. PEV, battery and interoperability testing.

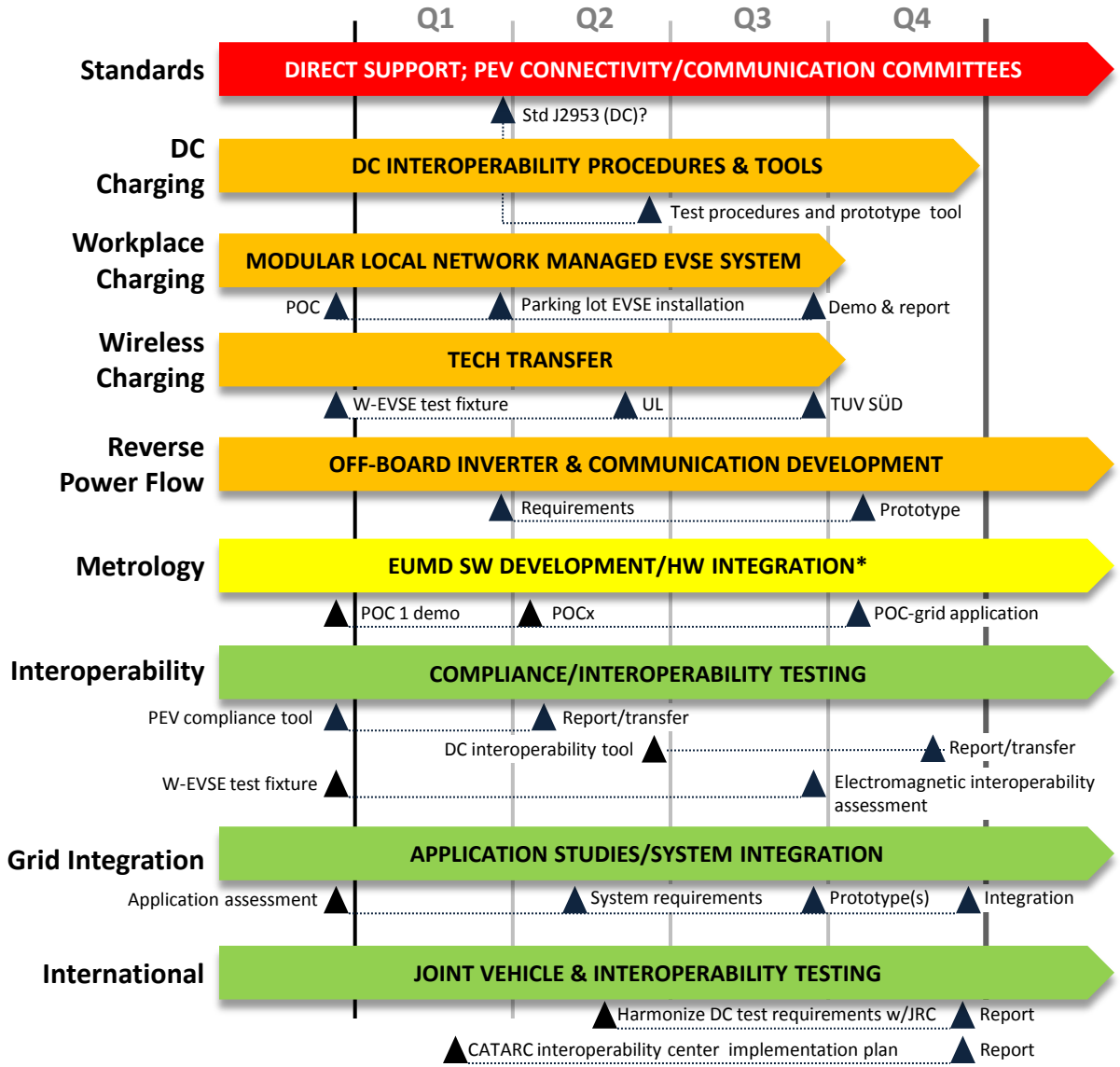
Response to FY 2013 Comments

- **Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways**
  - Reviewers noted that all work is focused on future standards; however there was some disagreement w.r.t. technical emphasis. One view was that interoperability and sub-metering were the most important (versus wireless charging); others recommended working on dynamic wireless (which is well beyond near/mid-term applications). ANL priorities are determined by the standards development schedule, DOE priorities and available technical resources.
- **Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**
  - Positive response…no issues
- **Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**
  - Reviewers felt resources adequately covered SAE activities, but more resources were need to support NIST, considering technology development (e.g., sub-metering). Monitoring and contributing expertise to NIST activities where possible are reasonable expectations, but Argonne support is at the discretion of DOE.

Remaining Challenges and Barriers

- **Lack of universal EV-EVSE compatibility and EV-EVSE-grid interoperability**
  - ***PEV-EVSE incompatibilities remain*** (some by design, e.g., Tesla); testing by Intertek will identify issues for many PEVs and EVSEs that are intended to meet the standards.
  - Standard EVSE-'grid' communication protocols have not yet been adopted due to the different methods of communication (e.g., satellite versus LAN) and competitive positioning of intermediaries (e.g., charging networks) utilizing proprietary interfaces/communication protocols.
- **Development and verification of technology and standards in time to support OEM and supplier production schedules**
  - ***The goal is to support data-driven standards development in a timely manner***; challenging because consensus on a standard often follows debate on the assumed enabling technology (due to prior internal decisions or IP issues) and standards are not independent of the choice of technology. In addition, the schedule to draft, review and adopt standards depends on the commitment to expert participation by industry.
- **Lack of harmonization in global markets with common OEMs and suppliers**
  - ***Differences in SAE (US) and IEC (EU) standards are being addressed***; the potential for harmonization with Asia is yet to be determined.

Proposed Future Work



FY 2015 Objectives

- **Consistent and harmonized AC & DC charging standards**

- **Transfer DC interoperability testing capability**
- **Verify network/energy management communication standards**
- **Standard W-EVSE testing capability at certification organizations**
- **Verify V2x standards for AC/DC**

- **Tech transfer**
- **Shift toward grid applications**

- **PEV J1772 compliance test capability**
- **AC/DC interoperability test capability**
- **W-EVSE field characterization and interoperability test capability**
- **System integration & demo at Argonne and NREL**
- **Harmonized procedures and tools**
- **Joint test reports**
- **Common global industry board**
- **Interoperability center at CATARC**

Summary

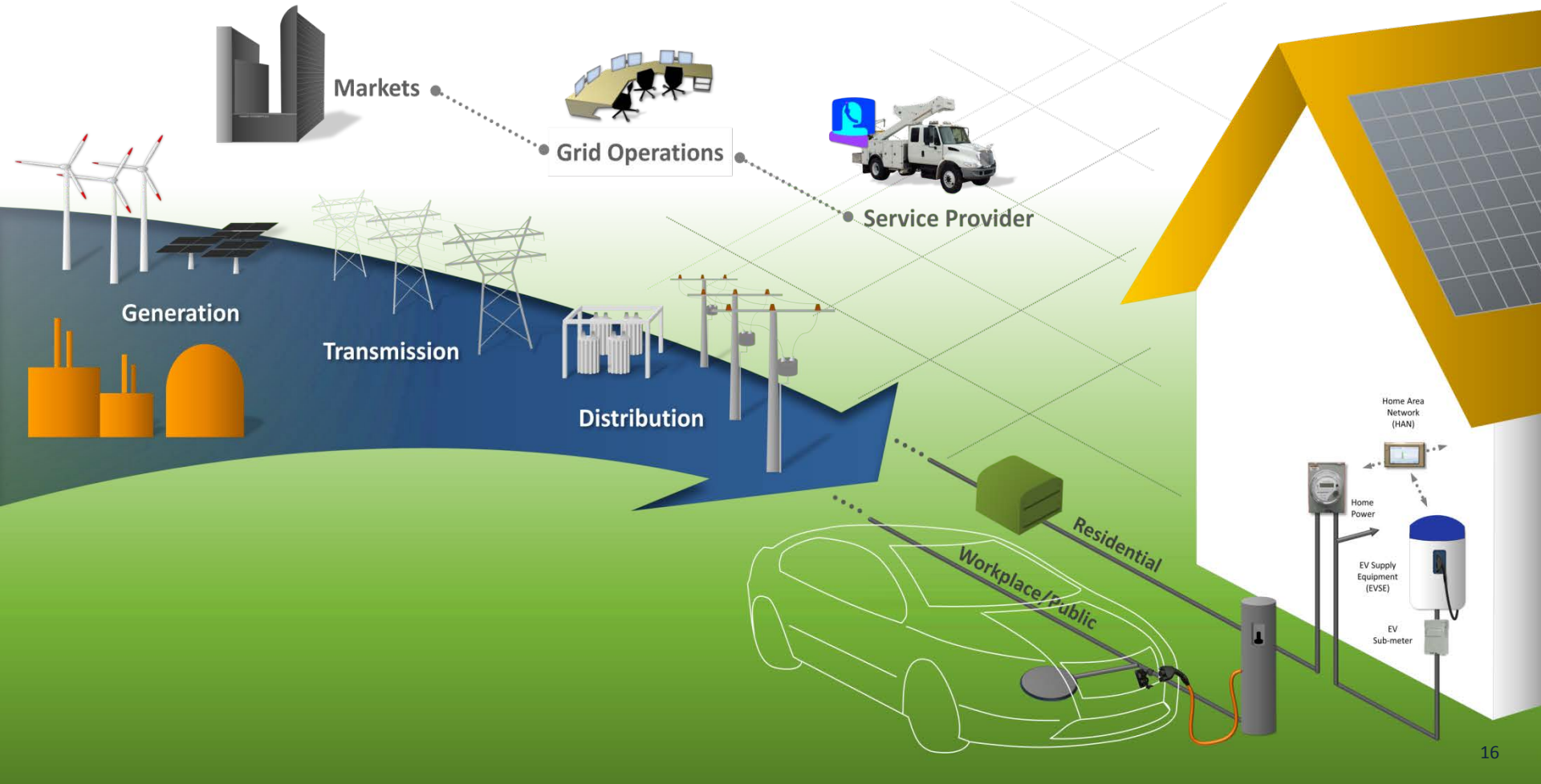
- **Relevance** – DOE technical resources (laboratories and expertise) are being applied directly to standards development and related needs of industry; the potential for global harmonization is enhanced by working level cooperation enabled by the establishment of cooperative interoperability centers.
- **Approach** – Activities are aligned with the needs of SDOs and industry; combining Argonne's unique embedded controls capability with the enhanced grid/vehicle lab has resulted in a venue that supports data-driven standards and the development of enabling technologies for grid connectivity and communication.
- **Technical accomplishments and progress** – Substantial progress was made in the development of procedures and tools to support vehicle connectivity and communication standards. Key enabling technologies were developed and licensed. The EV-Smart Grid Interoperability Center was launched and directly supports harmonization activities with Europe … and is the basis for discussions of a similar cooperative center in China.
- **Collaborations and coordination** – Activities are well-connected with industry and government agencies (domestic and international).
- **Future work** – Well-grounded; focused on near-term needs with long-term impact.

Technical Back-up

- Interoperability with the Charging Infrastructure
- Joint Research Centre-Institute for Energy & Transport Interoperability Project

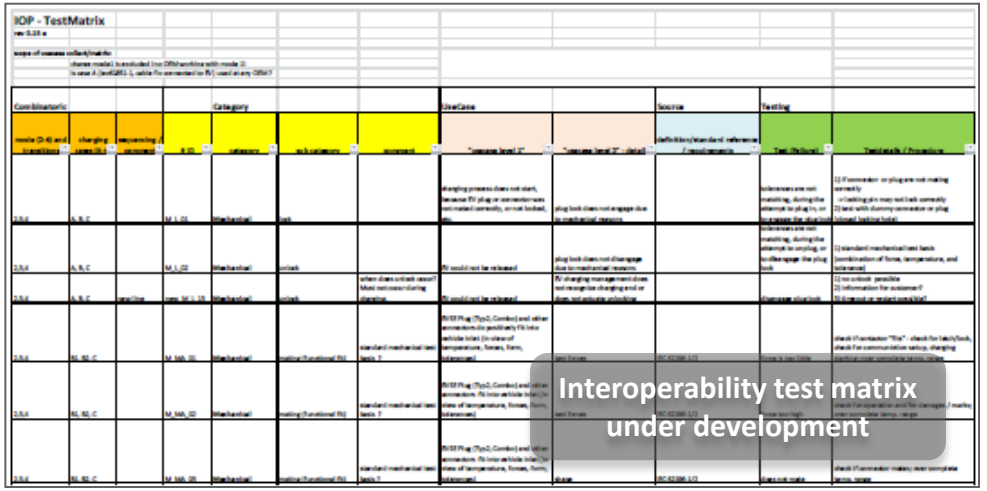
Interoperability with Charging Infrastructure

- EV-EVSE compatibility (connectivity and communication)
- EVSE-ESP interface consistent with smart grid
- No geographic or service constraints



Interoperability Project

Evaluating 'man-in-the-middle' test equipment



Interoperability test matrix under development

EVSEs in the cold chamber

Partner OEM vehicle under test

Reviewer-only

Publications/presentations since 2013 AMR slides were submitted

- Dobrzynski, D. and Harper, J., *Development and Implementation of J2953 for AC Charging*, SAE World Congress, SAE 2014-01-0184, Apr 2014
- Hardy, K., *Standardize to Realize EVs and Potential Grid Benefits*, EEI Transmission, Distribution and Metering, Scottsdale, Apr 2014
- Bohn, T. *EV Charging Standards Development and Status*, SAE World Congress, Apr 2014
- Bohn, T. and Hardy, K., *EV Charging Standards and Interoperability Verification; Update on Preferential Metering Advancements*, SAE Government-Industry, Jan 2014
- Hardy, K., Bohn, T., Slezak, L., Krasenbrink, A. and Scholz, H., *US-EU Joint EV-Smart Grid Interoperability Centers*, EVS27, Barcelona, Nov 2013
- Bohn, T. *EVSE-PEV Interoperability Standards Updates; Managed Energy Networks for EVSEs in Workplace and Multi Unit Dwelling Installations*; Mid-America PEV Exchange Meeting, Oct 2013
- Hardy, K., *EV-Smart Grid Interoperability Centers in Europe and the US*, Presentation to the High Level Joint EC Joint Research Centre and the US Mission to the EU meeting "Building a Transatlantic Scientific Bridge on Eco-Industries", Brussels, Sep 2013
- Hardy, K., Harper, J., Dobrzynski, D. and Bohn, T., *US EV-Smart Grid Interoperability Center* (launch, presentation and smart grid demo), Argonne National Laboratory, Jul 2013
- Hardy, K., *Government Initiatives to Support Transatlantic Harmonization of E-Mobility Standards and Technology ... Accomplishments and Future Direction*, Presentation, Baden-Wurttemberg Trade Mission to the US, Detroit, May 2013
- Hardy, K. and Krasenbrink, A., *Facilitating Standards Harmonization … the Launch of EV-Smart Grid Interoperability Centers in Europe and the US*, World Electric Vehicle Summit, Oslo, May 2013
- Bohn, T. *Systems of Systems: Confidence and Verification of Systems with PEV Charging Standards Examples*; UL Annual Meeting, May 2013
- Hardy, K., *EV-SG Interoperability Centers … to Facilitate Harmonization of Standards, Technology and Test Procedures,* Joint EU-US E-Vehicles Stakeholders Forum, Washington, DC, Apr 2013
- *U.S. DRIVE Grid Interaction Technical Team Roadmap*, Apr 2013